EVALUATION OF A MICRORING RESONATOR'S PERFORMANCE FOR OPTICAL SOLITON COMMUNICATION SYSTEM

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To my beloved mother

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ABSTRACT

Transmission of optical signals in today's telecommunication system is facing lots of technical problems. The solution lies on a particular type of light wave known as optical soliton. These light pulses will be the perfect solution for transmitting signals and also digital data in communication systems. Soliton has the ability to travel over long distances without being distorted. Microring resonators are introduced as a filter. Microring could be performed as the device for security purposes. By varying the transmission coefficients from 0.25 to 0.75, ring radius from 5μm to 15μm, and coupling coefficients, κ from 0.25 to 0.85, the performance of the ring resonator is examined in terms of free spectral range (FSR), Full Width Half Maximum (FWHM), Finesse (F), Quality Factor (Q) and time-domain at output signal. The conditions and controls to have a better performance of microring resonator were studied. Results obtained showed that to obtain a higher FSR and lower FWHM with maximum transmission are by using the ring radius of 15μm, the transmission coefficient of 0.75 and with the coupling coefficient of 0.25. In conclusion, the results obtained showed that the performance of the microring resonator are governed by the transmission coefficient, coupling coefficient, ring radius and time-domain factor.

ABSTRAK

Penghantaran signal optik dalam era telekomunikasi menghadapi pelbagai cabaran dan rintangan. Soliton dikenalpasti satu-satunya jalan penyelesaian yang boleh digunakan dengan meluas dalam penghantaran signal optik dan juga data digital dalam era telekomunikasi. Soliton juga boleh digunakan dalam penghantaran signal jarak jauh tanpa sebarang halangan dan rintangan. Penyalur cecincin mikro digunakan dalam saluran optik sebagai penapis. Ia juga digunakan bagi tujuan keselamatan komunikasi. Pembolehubah manipulasi dikaji dengan mengubah nilainya bagi pekali penghantaran dari 0.25 ke 0.75, jejari cecincin dari 5μm to 15μm, dan pekali gandingan, κ dari 0.25 ke 0.85, dan kesannya terhadap prestasi penyalur cecincin dikaji dengan parameter seperti FSR, FWHM, Finesse, Faktor Qualiti dan faktor domain masa. Syarat-syarat dan kawalan untuk mempunyai prestasi yang lebih baik bagi cecincin mikro dikaji. Keputusan yang diperolehi menunjukkan bahawa bagi mendapatkan FSR yang lebih tinggi dengan FWHM yang rendah dan dengan transmisi yang maksimum adalah dengan menggunakan jejari cecincin 15μm, pekali penghantaran 0.75 dan dengan pekali gandingan 0.25. Kesimpulannya, keputusan yang diperolehi menunjukkan bahawa prestasi cecincin mikro bergantung pada pekali penghantaran, pekali gandingan, jejari cecincin dan faktor domain masa.

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LIST OF SYMBOLS

E_{in}	- Inserted Electric field
E_1	- Electric field in waveguide
E_2	- Electric field in waveguide
E_{out}	- Electric field at output port
κ	- Coupling coefficient
t	- Transmission coefficient
α	- Linear Absorption coefficient
k	- Non-linear phase shift
L	- Length of ring resonator
r	- ring radius
n	- refractive index
n_0	- linear refractive index
n_2	- Non-linear refractive index
I	- Optical Power Intensity
P	- Optical Field Power
A_{eff}	- Effective mode core area of fiber

λ	- Wavelength
L_c	- Coupler length
F	- Finesse
E_{th}	- Electric field at throughput port
E_{drop}	- Electric field at drop port
E_{add}	- Electric field inserted at add port
P_{out}	- Output power at throughput port
P_{drop}	- Output power at drop port
P_{in}	- Input Power

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CHAPTER 1

INTRODUCTION

1.1 Overview

Computer technology is considered as a mega phenomenon that has colossal effect mankind. Computer technology and communication technology which are part of information technology can revolutionize the life of the society. One of the latest developments in the communication technology is the Nanotechnology.

For decades, Nanotechnology has been recognized as an interesting research subject in theoretical and experimental investigation. Many of the research works and implementations have shown the significant growth in nanotechnology. Nanotechnology is widely used in the field of communication.

As a result, it is almost impossible to imagine a world without the use of handphones, telephones, internet, radio for communication. Looking back at the history of communication, an electronic message was sent for a long distance by Samuel Morse and this led to invention of telegraphy. The year 1876, Alexander Graham Bell found a new way of transmitting speech over long distance[1]. Then as years passed, the number of calls increased and so did the demand for large scale facilities in communication. Here is where optical fibres come in[2]. Wires used in telecommunications were replaced with optical fibres due to the need for high speed and huge data transmit in communicational technology.

A lot of researches were carried out and are still in progress. Nowadays optical fibres can transmit very huge calls. However, the demand for it also growing very rapidly due to the growth of internet usages. Researchers are now focusing on fibre potentials to withstand current needs. Recently, researchers have fabricated a small waveguide named microring resonators and nanoring resonators as integrated into the optical fibre. It has shown the potential applications and seems a very good candidate in many research areas, especially in computer, communications and signal processing. The measurement and also the calibration of these devices and the applications are required to fulfil the system validity.

Soliton has been recognized as a nonlinear solitary wave for many years. It has been widely investigated in several subjects such as in physics, mathematics and also in communication areas, especially, in optical communication systems. Television telecasting and satellites are also using higher reliable light wave technology.

Generally, the common property of a soliton is known as self-phase modulation (SPM) is the challenge behavior. Furthermore, the key advantage is the non-dispersion behavior of soliton, which is capable in the use of long-haul communication. It’s no longer needed the use of repeater.

1.2 Background of the study

The use of optical soliton in communication has higher benefits especially for security and filtering purposes. The other interesting soliton behavior is the localization which is useful in many areas of applications. This means that the soliton pulse can be stored and trapped within the periodic medium. Theoretically, a soliton pulse can be recovered when the balance between dispersion and nonlinear lengths of the soliton pulse exhibits the soliton behavior which is known as self-phase modulation. This phenomenon occurs when the provided the matching between the soliton property and localized media. The greatest applications of research in science and technology will be undoubtful when the generation of the localized soliton pulse is achieved.

Recently, many reseachers are using the chaotic soliton to form a fast light generation within a tiny device called microring resonator (waveguide). Optical ring resonators are consists of a waveguide in a closed loop and coupled to one or more input/output waveguides. When a light pulse of a suitable wavelength is coupled to the loop by the input waveguide, it then builds up the intensity over multiple round-trips due to constructive interference in the loop. It then can then be picked up by a detector waveguide. Since only some wavelengths are resonating within the loop, it also can be functions as a filter. In practice, various areas are using this devices.

1.3 Statement of Problem

Optical soliton propagation in high beat rate communication system is thought to be the ultimate solution to transmitting the optical signals. Therefore, we would like to study the effects of parameter on the efficiency of mircoring resonator that is used in the optical soliton communication system. This research has new approach in identifying the suitable parameters for efficiency of microring resonators. Recently, many developments especially in communication system, are focusing on the design and also on the application of the microring resonators. However, the understanding of soliton propagation and its interaction with microring resonators is slightly imbalanced and poorly understood by many people. Therefore, we would like to investigate the performance of microring resonators.

1.4 Objectives of the study

1.4.1 General Objectives:

- To investigate the parameter dependent effects on the performance of the microring resonator that is used in optical communication system.

1.4.2 Specific Objectives

- To study the effects of Free Spectral Range(FSR), Full Width Half Maximum(FWHM), Finesse(F), Quality Factor, Coupling Coefficient, ring radius, and time-domain on the performance of Microring Resonator.
- To optimise model/design of microring resonator based for optical communication system.
- Tally our findings with existing observations.

1.5 Scope of the study

Recently, many researchers on microring resonators are workings on chaotic signal processing and cancellation of signals in secure communication system. The scope of our study will focus mainly on lights behaviours in nonlinear medium-microring resonator. Our input light will be soliton pulse. The interesting parts are varying the key parameters of microring resonators. The key parameters are free spectral range, finesse, coupling coefficient, ring radius, FWHM and quality factor. In this study, the effects of parameters changes and the effects on design changing of microring resonators will be studied. The dominant factors affecting the processes will then be identified. This study will lead to generation of clear and chaotic signals for communication systems and also as a filter in secured communication systems. This study will be fundamental for higher research in application of microring resonators.

1.6 Significance of the study

In a common process, electrons are used to transmit the signals which are considered as slow and ineffective compared to photonics. Most of the researchers, now focus on the signal security and transmitting digital data at a fast rate and in using efficient methods. This study will provide a vivid picture of the solitons and functions of the microring resonators in generating clear and chaotic signals. The communication security and the long distance transmission link in communication networks can be obtained by using this tiny device called microring resonator. This field of study can be categorized as a potential field in developing and enhancing network communication system in our nation. This study would provide direct benefits to our progress and development of science and technology.

1.7 Organization of thesis

This thesis report is organized as per follows. Chapter 1 is the research framework. This chapter discuss on the introduction to our study, a description to the problem, the objectives of the study, the scopes of the study, the significance of the study and finally the organization of thesis.

Chapter 2 is briefing about the theory that pertains to this work, solitons and microring resonators, embracing past researches that has been done related to this study. Chapter 3 is elaborating the complete account on the research methodology that is used in this study. Chapter 4 is the reports on findings and its analysis. Finally, Chapter 5 gives the conclusions for our overall study.

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